

evident that each division will be equal to $\frac{0.08}{15} = 0.0053$ mgr. This fraction is, therefore, the titre of this scale. Dissolving 5 mgr. of a mineral containing manganese and nothing that could interfere, we find the point of extinction at 17, then we have percentage p of Mn_2O_3

$$p = \frac{(0.0053 \times 17) \times 100}{5} = 1.802.$$

In a subsequent paper I shall give tables and determinations for a number of important minerals and ores. As the determinations will have to be made, for the most of them, in the humid way, the labor will be extensive and time consuming. I should esteem it a great favor if my co-laborers in mineral chemistry would furnish me with such small samples of minerals and ores analyzed by them and coming within the limits of this method. In so much as each worker multiplies himself, so to speak, by lessening the time consumed in determinations, I cannot but consider this chromometric method as of the greatest importance, and again ask for active co-operation in its further development. Thus far I have proved the method thoroughly only for manganese, iron and chromium. The former offers no difficulty and gives equally accurate results with the most approved gravimetric methods. I shall next extend it to copper ores.

Crucial Harmonies. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(Read before the American Philosophical Society, October 4th, 1878.)

No surer test of any hypothesis has ever been suggested than its furnishing a successful anticipation, or prediction, of facts or phenomena that were previously unknown.

The harmonic progression, which starts from Jupiter's centre of linear oscillation as a fundamental unit and which has 4 for its denominator-difference, was taken as the ground for such a prediction, in the communication which I read to the American Philosophical Society on the 2d of May, 1873.* Kirkwood had, a short time before, computed a probable orbit for "Vulcan," which satisfactorily represented the second interior term of the series, and this accordance was one of the principal sources of the confidence with which I ventured upon a publication of the prediction.

Forty-one days afterwards, on the 19th of June, De la Rue, Stewart and Loewy communicated to the Royal Society certain conclusions, based upon three sets of sun-spot observations, taken in three different years, and extending over periods, respectively, of 145, 123 and 139 days. Those observations indicated some source of solar disturbance at .267 of Earth's mean radius-vector, which represented the first interior term of my series and gave the first conclusive verification of my prediction. In announcing

* Proc. Soc. Phil. Amer., xiii, 238.

this fact to the Society, I presented three nearly identical series, the first being determined solely by Jupiter, the second by Earth, and the third by relations of planetary and solar masses.* I gave precedence to the first of these series, both because of Jupiter's predominant importance and because of the many planetary harmonies which are determined by Jupiter's mean perihelion.†

At the time of the late total solar eclipse, Watson and Swift each observed two small planets between the orbit of Mercury and the Sun. By comparing the published position of the planet which was first announced by Watson, with some of the most trustworthy of the recorded observations which were thought by Leverrier to indicate intra-Mercurial transits, Gaillot and Mouchez found an orbital period of 24.25 days,‡ which represents the third interior term of my series and the second strict verification of my prediction.

The relatively rapid motion of Phobos, the inner satellite of Mars, and the probably meteoroidal nature of the corona, may reasonably lead us to look for an indefinite number of further verifications in the results of future discovery. No other known medium possesses so great a degree of elasticity as the hypothetical luminiferous æther; none other is, therefore, so well fitted for the production of musical, or rhythmical harmonic vibrations. Numerous evidences of intelligent arrangement and design have been pointed out in the solar system. They all indicate important laws, but none show so close and general accordance with actual planetary positions as those which most accurately record the "music of the spheres."§

I submit the following table, both as evidence of the foregoing statements and as a possible help towards the discovery of new planets or the determination of their orbital periods.

No.	Harmonic Prediction.	Confirmation.
1	$\frac{2}{3}$ Jupiter = $\frac{1}{3}$	Node of Subsidence, 3.469
2	$\frac{1}{3}$	Venus m. p. .698
3	$\frac{1}{9}$	Mercury m. .387
4	$\frac{1}{18}$	De la Rue, S., and L. .267
5	$\frac{1}{17}$	Kirkwood, .209
6	$\frac{1}{21}$	Watson, .164
7	$\frac{1}{25}$
8	$\frac{1}{29}$
1 ₁	$\frac{1}{33}$	Helios, .106
2 ₁	$\frac{1}{177}$	Themis, .0196
3 ₁	$\frac{1}{321}$	Eunomia, .0108
4 ₁	$\frac{1}{405}$	Phaos, .0074
5 ₁	$\frac{1}{609}$	Lychnis, .0057
6 ₁	$\frac{1}{753}$	Sun's surface, .004606

* Proc. Soc. Phil. Amer., xiii, 470, 472.

† Ibid, 239.

‡ Comptes Rendus, 5 Août, 1878.

§ Proc. Soc. Phil. Amer. xiii, 474.

m, *meta* . p. *perihelion*.

The harmonic denominators for Nos. 1-8, etc., are of the general form $4n-3$. The denominators for Nos. 1_1-6_1 , are of the form $4p-3$; p being equal to 9 ($4n-3$). The first term of the second series, or the 9th term of the first series, gives the orbital distance of a planet which would revolve about the sun synchronously with a solar half-rotation, a period which seems to be determined, as we have already seen, by the action of LIGHT.

The term 2_1 , or the 45th term of the first series represents the orbital distance of a planet which would revolve in a sidereal day, or synchronously with Earth's rotation on its axis. The corresponding planet may be fitly named Themis, in honor both of the daughter of Ouranos and Gaia, and of her character as goddess of law and order.

The term 3_1 , or the 81st term of the first series, marks the orbital distance of a planet which would have an orbital period synchronous with Jupiter's rotation on its axis. Its designation has also a double fitness; Eunomia having been the mythical daughter of Jupiter and Themis, and her name signifying "good government."

The term 4_1 , or the 117th term of the first series, gives the position of a planet which would have an orbital period twice as great as if it were at Sun's surface.

The term 5_1 , or the 153d term of the first series, represents a planet which would have an orbital period determined by Herschel's "Subsidence" from opposite extremities of an early solar diameter.

The term 6_1 , or the 189th term of the first series, represents the present surface of Sun, provided the depth of the photosphere is one per cent. of Sun's radius.

The denominator of the one hundred and eighty-seventh term of the first series ($1+186 \div 4=745$), which terminates the intra-telluric series, represents the ratio of the aggregate planetary mass to Sun's mass.

Herschel's modified statement of the nebular hypothesis and Gummere's criterion, not only furnish ground for a satisfactory explanation of such remarkable velocities as that of the inner moon of Mars,* but they also seem to require that secondary orbs, when they revolve in less time than is required for the rotation of their primaries, should be denser than the primaries. I find, therefore, good reason for anticipating that Phobos, as well as any yet unknown possible moons of Mars which have an orbital term of less than a day, will be found to be more dense than the planet itself.

That these accordances find a *vera causa* in the harmonic undulations of the luminiferous æther, is made still more evident by the constant solar equation, ${}_1gh = gt = \text{velocity of light} : g$, representing Sun's superficial gravity at any stage of nebular condensation, past, present, or future; h , solar modulus of light; t , time of corresponding rotary oscillation, or half-rotation; t , is also time of traversing $\frac{1}{2}$ modulus of light, or $\frac{1}{2}$ mean luminiferous æthereal atmosphere, under the constant acceleration g .

* Proc. Soc. Phil. Amer., xvii, 302, 312, etc.